BLEYER (J. M.)

Reprinted from the New York Medical Journal
for April 25, 1896.

AN ABSTRACT OF A LECTURE ON THE NEW RAYS OF RÖNTGEN, THE NEW PHOTOGRAPHY, AND THE PHOTO-FLUOROSCOPE;

THEIR JOINT APPLICATION IN MEDICINE.

Delivered before the Medico-legal Society, April 15, 1896.

BY J. MOUNT BLEYER, M. D., F. R. A. M. S.,
MEMBER OF THE SOCIÉTÉ FRANÇAISE D'OTOLOGIE, DE LARYNGOLOGIE, ETC., PARIS, ETC.

[After a few introductory remarks, Dr. Bleyer spoke substantially as follows:]

ALLOW me to call your attention to some early work on the invisible rays. It is known that the force which we call light is not a tangible entity that we can lay hold of like a piece of wood; it is a very rapid wave motion or vibration of a hypothetical medium called the luminiferous ether, which motion, communicated to the retina, gives rise to a sensation which we call light.

We are accustomed to speak of substances as being opaque, translucent, or transparent, but these terms are not absolute by any means, as will be seen from the following statement: A sheet of gold of, say, an eighth of an inch thickness appears to us to be opaque—that is, we can not

see through it; ordinary glass, on the other hand, we can see through. But reduce the gold to a thin leaf by rolling and hammering, and it allows light to pass through; increase your glass to a very great thickness and it becomes absolutely opaque, or allows no light to pass.

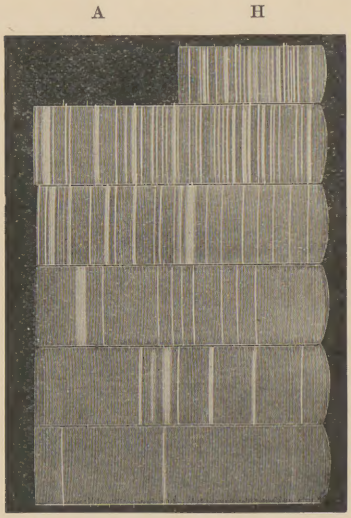

FIG. 1.—Spectrogram of the spectrum of cadmium (from the *Photogram*).

We speak of daylight as white light, but if a narrow slice of daylight is allowed to fall upon a prism, we obtain a band of colors, ranging from a deep crimson red, through orange, yellow, green, and blue, to violet, which band is called the spectrum. When sunlight or daylight is examined in this way, the spectrum is found to be crossed by numerous transverse dark lines, which may be popularly described as landmarks or milestones. Of such a comparatively finite nature is our sight or brain that we can only discern a very small portion of the spectrum; that is to say, as long as the vibratory motion lies within certain limits we are sensible of the same as light, but at either end beyond these limits stretch fields utterly away from our visual sensations, but they can be detected by other means, such as photography.

In the spectrogram of the spectrum of cadmium (Fig. 1), as made by J. W. Gifford, of London, we have a repro-

duction of a photogram of the spectrum. This illustration shows that the only portion which can be seen by us is that part lying between A and H. It has been demonstrated that there are vibrations or waves far beyond this origin, as is shown by photography. In this region beyond H, or the violet, it stretches at least nine or ten times as far; how much farther we can not say. Langley's spectrum, which he made by means of his bolometer, shows us the red at one end, and in the infra or invisible red region an extension of fourteen times the length of the visible spectrum, as seen in Fig. 1.

Professor Langley, of the Smithsonian Institution, has given us some very valuable information in regard to the spectrum of invisible light by his most ingenious invention, the bolometer. This device, as used by him, consists of an instrument for measuring minute differences of radiant heat by changes in the electric resistance of a blackened conductor exposed to it. It consists of a series of plates of metal connected with a battery and a galvanometer, to the latter being attached a very minute concave mirror, on to which is thrown a narrow pencil of light. When the spectrum falls upon the blackened surface connected with the metal plates, the electric resistance is changed, the galvanometer is deflected, and the spot of light reflected from the concave mirror, which is hung upon a very fine quartz fibre, is received upon a photographic plate. On development, a figure like the chain of mountains shown in Fig. 2 above the spectrum is obtained, from which the line spectrum (called a bolograph) is constructed. The theory is that where the infra-red spectrum falls there is a development of heat, but where the Fraunhofer lines occur there is no heat, and therefore there is a deflection of the spot of light. With the bolometer it is possible to measure a dif-

ference of heat of a hundred-thousandth of a degree of Fahrenheit's thermometer scale.*

FIG. 2.—Langley's normal bolometric spectrum, showing curves of galvanometer deflections (from the *Photogram*).

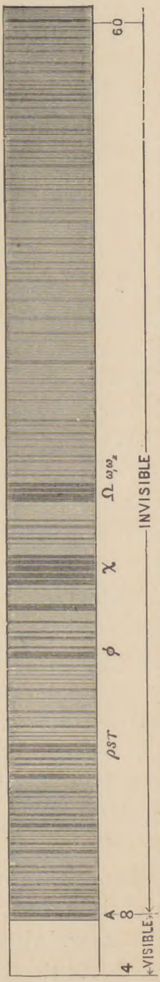

FIG. 3.—Langley's latest spectrum. The white portion on the left is the visible spectrum, the shaded portion on the right representing the invisible or infra-red (from the *Photogram*).

* E. J. Wall, F. R. P. S. *Invisible Rays.* London.

In experiments made by the late Professor Tyndall, in his most popular lectures at the Royal Institution, he concentrated the invisible red rays from an electric lantern, and in their focus fused and burned many metals. Captain Abney also photographed, in an absolutely dark room, a kettle of boiling water, by the same infra red rays.

The close connection between light and electricity has long been known, for Clerk Maxwell enunciated the theory that light itself was but an electro-magnetic phenomenon, and that what we called waves of light were not mechanical waves at all, but were immensely rapid electric displacements taking place in the all-pervading ether of space; and Professor Sylvanus Thompson states it as his opinion that with further developments of the theory it would be found to satisfactorily explain all the phenomena of light. That electricity generates light or vibratory wave motion is, of course, common knowledge, and that electricity is itself but a wavelike motion has been shown by the classic experiments of Hertz, who proved still further the similarity of electricity to light by reflecting and refracting the waves of electricity he generated just as if they had been light-waves.

We can not see electricity, and we can not see the ultra-violet and infra-red rays, but we can prove the existence of the same by very easy experiments. In the case of electricity, the famous researches of Hertz have placed the existence of these electrical waves beyond doubt; the existence of the infra-red light waves has been proved not only by photography, but also by Professor Langley's bolometer, and the results obtained by this as well as by photography in the ultra-violet.

Besides, however, these waves or rays, there are others directly connected with the phenomena of electricity which become distinctly visible under certain conditions. If we

take a glass tube and pass a wire through each end and close the ends up, and then draw the air off by a fine aperture so as to leave, as far as we can, very little or no air remaining, we have what is known as a Crookes's tube; and on passing a current of electricity through this, we obtain some striking phenomena. For instance, from the anode, or positive pole, of the battery, induction coil, or static machine supplying the current, we have a series of beautiful striations or *striæ* of light, which vary in color with the gas, a small residuum of which remains in the tube. These, however, have but little interest to us. From the cathode, or negative pole, proceeds a stream of rays which have some extraordinary properties, and have received the name of "cathode rays." In the first place, these cathode rays cause the most brilliant phosphorescence even in glass, but on certain well known chemical products the light is extremely brilliant, and it is possible, by the interposition of screens or patterns cut to a particular shape, to obtain sharp, clear-cut shadows of the patterns. Further than that, if a series of light vanes or paddles is mounted on an axis inside of these tubes, they will rapidly rotate like the well-known radiometer or light mill. Then, again, these cathode rays have the property of passing through thin metallic foil in an absolutely straight line, and exciting fluorescence when allowed to fall upon paper saturated with various chemicals, such as platinocyanide of barium or tungstate of calcium. Herr Lenard, of Hungary, examined these rays in 1864, and conducted numerous experiments. By placing the ordinary photographic plate and sensitive paper behind various substances, such as aluminum, wood, quartz, etc., he was able to obtain shadow images, or photographs, so called, showing the permeability of these substances to these rays.

On applying an ordinary magnet to these rays, it was

found that they were deflected or attracted by the magnet. Practically, then, we have come back to one of our first statements—namely, that the terms opaque, translucent, and transparent are but relative; they are practically interchangeable under certain conditions; for quartz, which is quite transparent to ordinary light, is absolutely opaque to these rays, and aluminum and cardboard of such a thickness as to be opaque to ordinary light are transparent or translucent to these rays.

This brings me to the point of considering in a concise manner the new light of Röntgen, the new photography, the fluoroscope, and their joint application in medicine and surgery. It is but a few weeks since the world was startled by the statement from Professor Röntgen that he was able to photograph through opaque objects. Naturally, this gave rise to considerable incredulity and fun at the expense of the learned professor, and even some of the shining lights in the scientific world were not loath to show their erudition by discounting the discovery, and ascribing the effects to the ultra-violet rays and the electric waves of Hertz. The discovery of these new rays, which bear the now famous name of Röntgen, was due, as is so often the case, entirely to accident. He was experimenting with a Crookes's tube wrapped in an opaque material, and on his bench lay a piece of sensitive paper on which he found, after a powerful current had passed through the tube, that a black line had been formed on the paper. Keenly alive to all extraordinary phenomena, the observant professor proceeded to investigate, with the result of the discovery of what is practically something absolutely new, the value of which we can not at present entirely begin to appreciate.

Now as to the difference between the cathodic and the "X" rays of Röntgen. The essential differences and similarities between the cathodic rays and "X" rays may well be

seen from his original communication. Nevertheless, a brief summarizing of these facts will bring them again before your notice. Röntgen light is not deflected by magnets, cathodic rays are; Röntgen rays are not absorbed or diffused so readily as cathodic rays. The Röntgen light will traverse several centimetres of wood and several millimetres of metal or glass, while cathodic rays fail to pass through any but thin films of glass, aluminum, etc. The Röntgen rays excite fluorescence and give shadow pictures at a distance of many inches, and even feet, from the Crookes's tube, while the cathodic rays are absorbed or diffused at a distance of fifty inches. The cathode rays proceed from the cathode itself, while, according to Röntgen, the "X" rays do not proceed from the cathode, but from that part of the glass where the cathode rays strike. The main points of similarity between the two are their powerful action on photographically sensitive films and their rectilinear propagation, as shown by the sharply defined shadows.

How are these cathode rays formed?

The air is a bad conductor of electricity, and when the latter passes across an air space we observe a brilliant spark; but, as has been stated, by exhaustion of the air the character of the discharge is altered, a fact first discovered by Hittorf and worked out by Plücker and Geissler, whose tubes are well known. Fantastic patterns are formed inside a vacuum, distinctly visible in various colors because of the peculiar nature of the glass or fluid which surrounds them. In 1879 Crookes replaced the cathode wire with a small flat or plane surface, and thus obtained a cylindrical beam of light which, proceeding in a straight line till it reached the opposite wall of the tube, behaved itself rather like a magnetic rod than like light, and possessed an elasticity of extraordinary character. The one end was closely connected to the negative electrode, the other, however, was free.

It has been well known for some time that this "magnetic rod," or cathodic light, was extremely rich in ultra-violet rays, and that it possessed the power of exciting fluorescence and setting up chemical action. To explain these phenomena, Crookes assumed that this stream of light was caused by a continuous stream of molecules of gas of enormous rapidity, proceeding from the cathode, while in a Geissler tube, which contained more gas, this repulsion of the gas molecules from the negative pole was to some extent accompanied by continuous collisions of the gas molecules. This hypothesis received a decided blow by the discoveries of Hertz and Lenard. Hertz stated that it must be possible to produce this phenomenon outside the vacuum tube, and that, being engendered in the tube, it must extend into the surrounding air. Lenard tested this experimentally, and found a substance which would allow the cathode rays to pass into the air. He obtained a Crookes's tube, and at the end opposite the cathode, where these rays struck, he replaced the glass with a sheet of aluminum, which was of about the thickness of gold leaf, but was at the same time absolutely impervious to gases. By placing in the path of any rays which might proceed from this aluminum window a piece of paper soaked with a fluorescent substance, Lenard proved conclusively that Hertz's assumption was correct, and that Crookes's explanation of the continuous stream of gas molecules was no longer tenable. Röntgen's grand discovery followed all this.

Now, having fairly touched upon the main principles and theories associated with these light rays, I shall call your attention to the screen, or fluoroscope.

The accidental discovery of the phosphorescent screen by Röntgen and Lenard, and the latest improvement upon it by Thomas A. Edison, called by him the fluoroscope, are

the outcome of the phosphorescence tubes. They are simply tubes filled with certain phosphorescent powders and hermetically sealed. When the tubes are observed in a dark room (and of course before exposure to light), they are invisible; if, however, a piece of magnesium wire is burned close to the tubes, they will be found to shine in the dark and to emit various colored rays of faint light. To this curious effect is given the name of phosphorescence; and the same result is also obtained when they are exposed to sunlight. The chemical substances which possess the property of developing light after exposure to light are called phosphori. There are many forms of these substances known to us, prepared differently and bearing different names. The phosphorescence of these various bodies, unlike that of the curious element phosphorus, is produced independently of any chemical change; if they are inclosed in sealed glass tubes and excluded from light, they retain the property of showing phosphorescence for many years, while the light emitted from phosphorus is due to the slow oxidation of this element. On placing it in water or in nitrogen, the light is no longer produced. This question of on what principle it is possible to explain the cause of the emission of light after exposing phosphorus to the sun or any brilliant artificial light has given rise to several theories.

The most rational one suggested is that the undulations of light convey their own vibratory motions to the phosphori, just as one musical instrument may cause another to vibrate sympathetically with it, and phosphorescence is observed so long as the substance continues to vibrate in a dark room, and without a constant accession or supply of vibratory power the light becomes fainter and fainter until it is no longer capable of affecting the eye; the vibratory power, like any other mechanical motion, must come to an

end when cut off from its source of power, the sun or the burning magnesium, which originally set it in motion. This opinion is further confirmed when we take into account the large number of substances which may become phosphorescent in a tolerably high degree. If this property was confined to a few bodies, the theory might not be so applicable ; but if it is agreed beforehand that any particles may become luminous if they are capable of entering into that state of vibration which we suppose belongs to the sun and to artificial sources of light, then it can be understood why the great number of organic or inorganic substances are all considered to enjoy in a limited degree the property of phosphorescence after exposure to the sun. Gmelin enumerated a large number of chemical bodies and common substances when he spoke of those things which became phosphorescent by irradiation. Also Edison examined 1,800 substances and found seventy-two that were fluoroscent.

Now that we have traced the principle underlying the phosphorescent screen, or fluoroscope, a brief outline of this invention is in place. This screen is in its latest dress, as designed by Edison. It consists of a flaring box, curved at one end to fit over the forehead and eyes like a stereoscope. The end of the box is closed by a pasteboard cover on the inside of which is spread a layer of tungstate of calcium, which, according to the inventor's report, has been found to possess six times the fluorescent power under the influence of the "X" rays that barium platinocyanide has.

The practical applications of the screen are many. For simple illustration purposes, one has but to place the object to be observed in front of the screen and behind the vacuum tubes in a fluorescent state. The shadow is formed on the screen and can be observed at once. In

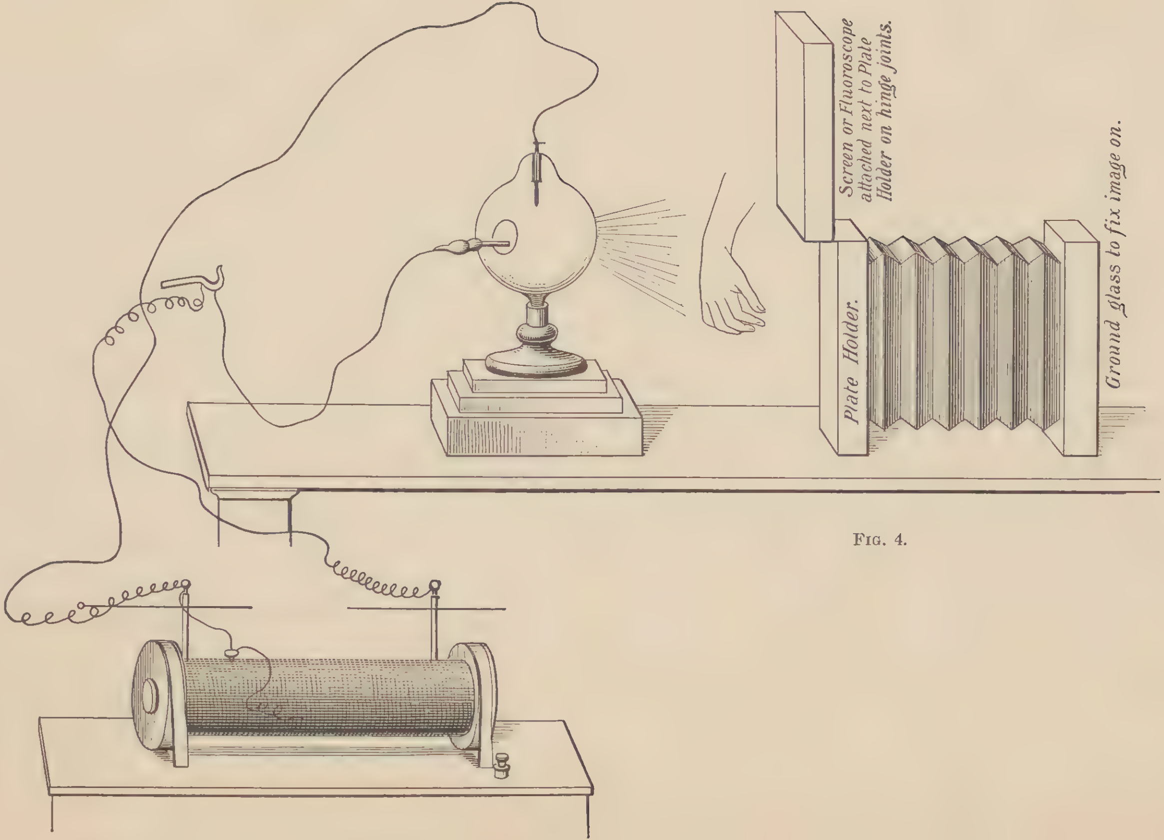
Screen or Fluoroscope attached next to Plate Holder on hinge joints.
Ground glass to fix image on.
Plate Holder.

FIG. 4.

order to exclude all light from the screen, the curved part around the eyes is encircled by a lining of feathers.

The photo-fluoroscope is an instrument which differs from all other fluoroscopes in the fact that it allows a direct shadow picture to be taken from the screen on the fluoroscope, after it is focused through the screen, and the image is seen on the ground glass in the photographic focusing box. With this device it is possible first to see and judge of the object to be photographed, instead of making a picture blindly—that is, without knowing what is in the negative until it is developed. The Röntgen rays, when they pass through the screen, reach the ground glass by first passing through the object. When this is done, the sensitive plate in a holder is exposed next to the screen, and then allowed a certain time of exposure.

The illustration shows the arrangement of the model. It consists of a photographic focus box, and ground glass, mounted on a movable table. To this box is attached on hinges a door, carrying a fluorescent screen, which closes directly over the sensitive plate. Just in front of the screen there is room for the object to be pictured, also a holder for placing the Crookes's tube at any distance. The coil is on the same stand.

The Röntgen method has not these advantages; by it one can never know what the result is to be until the negative is developed. The time of exposing the plate is much shorter, and there are many other important considerations which make it particularly fit for the physician's work.

In many diseases of the chest, throat, and nose the diagnosis is often doubtful, especially in the bony and cartilaginous parts. There is no doubt in my mind that this process will aid us as much as it already has proved to be of great service in general surgery.

In the study and application of these rays and shadow photography in medicine and surgery the possibilities which were opened to us by this discovery are startling. No one can yet foreshadow the coming researches to be made.

From what has been said and demonstrated thus far we can readily enough understand the lessons taught us by these various methods of taking Röntgen pictures and viewing opaque objects with the screen and Crookes's tube.